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ABSTRACT

This study investigates whether words differing in a single contrastive semantic feature (positive/negative) can be discriminated by auditory evoked responses (AERs). Ten right-handed college students were provided with auditory stimuli consisting of 20 relational words (more/less; high/low, etc.) spoken with a middle American accent and computer modified to match peak intensity level and duration. A microcomputer simultaneously presented the recorded words and provided visual stimuli consisting of pictures of eight configurations of two rectangles, shown with the larger or taller rectangle on the right and left sides of the picture an equal number of times. Scalp electrodes monitored brain and eye activity. Analysis of the results showed the subjects reliably discriminating between words differing in the semantic feature in question, supporting the semantic feature hypothesis that suggests words may be decomposed into more basic elements. It appears that both hemispheres in the parietal region are sensitive to the kinds of features exemplified by these relational word pairs, and that the AER procedure could be quite useful in studying the semantic component of language. (MSE)

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A STUDY OF SEMANTIC FEATURES: ELECTROPHYSIOLOGICAL CORRELATES

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A STUDY OF SEMANTIC FEATURES:
ELECTROPHYSIOLOGICAL CORRELATES

One theory attempting to describe word meaning is the semantic feature hypothesis. According to this hypothesis, words are represented (in the brain) as bundles of elementary semantic components, or features, in a manner analogous to that which Chomsky and Halle proposed in THE SOUND PATTERN OF ENGLISH (1968) for the representation of speech sounds. With a finite set of basic features, then, any word could be described (and represented in the brain) by a particular configuration of markings indicating the presence or absence of each of these features. For example, the word "man" would be characterized by the features "+ human, + adult, + male", among others. "Man" would be distinguished from the word "boy" by the presence of the feature "+ adult", "boy" being specified as "- adult".

Much of the research on semantic features has involved relational word pairs that signify opposite ends of various continua or scales; such word pairs

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include "high - low", "front - back", "long - short", "more - less", etc. The pair "high - low", for example, represents opposite ends of a height scale, "high" describing the positive end, "low" the negative end. (One way to think of the positive/negative distinction is that, for such positive words as "high" or "long", something must be added to make it high or long, whereas for negative words, "low" or "short", something must be subtracted to make it low or short.) Those adjectives describing the positive ends of scales would have the feature "+ or positive", whereas their negative counterparts would be characterized as "- or negative".

The purpose of this study was to investigate whether words differing in a single contrastive semantic feature, namely "+/- (positive/negative)", could be discriminated by auditory evoked responses (AERs).

METHODS

The subjects for the study were 10 undergraduates

with a mean age of 21.5 years. All were strongly right-handed based on their responses to the short form of the Edinburgh Handedness Inventory proposed by Oldfield (1971); the mean laterality quotient for all subjects was 81.6. Subjects had normal, uncorrected vision as determined by self-report and visual testing. Subjects also had normal hearing with comparable sensitivity for the two ears, determined by air conduction threshold tests.

Ten pairs of relational words provided the 20 auditory stimuli used in the study: "more, less; high, low; wide, narrow; above, below; deep, shallow; front, back; up, down; over, under; before, after; tall, short". (The first word in each of the above pairs represents the positive condition, the second word the negative.) A t-test comparing the frequencies of occurrence of the positive and negative words as listed by Kucera and Francis (1967) showed no significant difference between the two conditions. Each stimulus word was spoken with a middle American accent and computer modified in order to match all words in peak intensity level and duration (550 ms). Four repetitions of each word were recorded in a block

randomized order on one channel of a cassette tape with an ISI varying randomly from 15 to 25 sec. A 16-ms pulse generated 60 ms before each word was recorded on the other channel. This trigger pulse served both to signal a PDP 11/34 computer to sample a given segment of brain activity and to signal an Apple II+ computer to present a picture after some varied interval. The pictures employed as visual stimuli in the study were eight different configurations consisting of two rectangles, one on the left side of the computer screen, the other on the right side. The two rectangles in each picture differed from each other either in width, height, or position. There was an equal number of occurrences for when the wider, taller, or higher figure appeared on the left side and when it appeared on the right side.

PROCEDURES

Scalp electrodes were placed at ten sites -- F3, F4, F7, F8, T3, T4, T5, T6, P3, P4 -- according to the Ten - Twenty system (Jasper, 1958); these were

referred to linked ears. Two electrodes were also placed supraorbitally and canthally in relation to the right eye in order to monitor eye movements. An electrode on the forehead served as ground. Electrode impedances were checked both before and after testing: electrode impedance differences did not excede 1 kohm. The scalp electrodes were connected to individual isolation units and from there to individual amplifiers; total amplification was 50,000x.

Subjects were seated in a dimly lit, sound-attenuated room, positioned approximately 1 meter beneath an audio speaker and in front of an Apple II+ computer. During the experiment, each word was followed by a picture of two rectangles displayed simultaneously on the Apple monitor. The subject was instructed to press one of two previously designated keys on the Apple keyboard to indicate which of the two rectangles in the picture best represented the word he had just heard. The Apple computer recorded the behavioral response to each trial while the PDP 11/34 recorded on-line the AER to each auditory stimulus. The PDP was also used to average the data. Subsequent statistical analyses were performed on an

IBM 370 computer.

RESULTS

Three independent statistical analyses were performed. A Principal Components Analysis-Analysis of Variance (PCA-ANOVA) combination was the initial analysis conducted. Two additional statistical procedures were used to check the reliability and internal consistency of the results of the PCA-ANOVA. These were a stepwise discriminant function analysis using a jackknife procedure, and a Monte Carlo-like random analysis.

AERs for all subjects were digitized at a rate of 5 ms for 100 points (500 ms) and averaged according to electrode site and word condition (+ or -); this produced 200 average AERs. The amplitude values of the 200 average AERs were the input to a Principal Components Analysis (PCA) with covariance matrix and varimax rotation. The PCA yielded six factors which accounted for 82.4% of the total variance (Fig.1). The centroid, or grand mean for all subjects,

electrode sites and conditions, represents activity common to all of the AERs; the factors represent the residual variance in the AERs.

Factor scores were computed for each of the 200 average AERs for each of the rotated principal components; these served as the dependent variables in independent repeated measures ANOVA with a hemispheres (2) by electrode site (5) by word condition (2) design. Only effects below the $p < .025$ level were considered to reduce the possibility of type I error. Factor 4, accounting for 15.27% of the total variance, was characterized by a word condition x electrode site interaction which was significant at a $p < .023$ level. Scheffe comparisons indicated that the parietal sites of both hemispheres reflected changes in the AERs at about 300 ms which discriminated between positive and negative features ($p < .006$). As can be seen with the data from the two subjects shown in Fig.2, the general effect is a heightened third positive wave for the negative condition only. No other effects were found relating to word condition.

The results of the other two statistical analyses performed substantiated the results of the PCA-ANOVA,

indicating that the results were not artifacts of the analysis.

DISCUSSION

The AER data support the semantic feature hypothesis, suggesting that words may be decomposed into more basic elements. It appears that both hemispheres, in the parietal region, are sensitive to the kinds of feature differences exemplified by these relational word pairs. The results obtained in the study cannot be attributed to artifacts of the analyses since comparable results were obtained with different analyses. The AER procedure could thus be quite useful in studying the semantic component of language.

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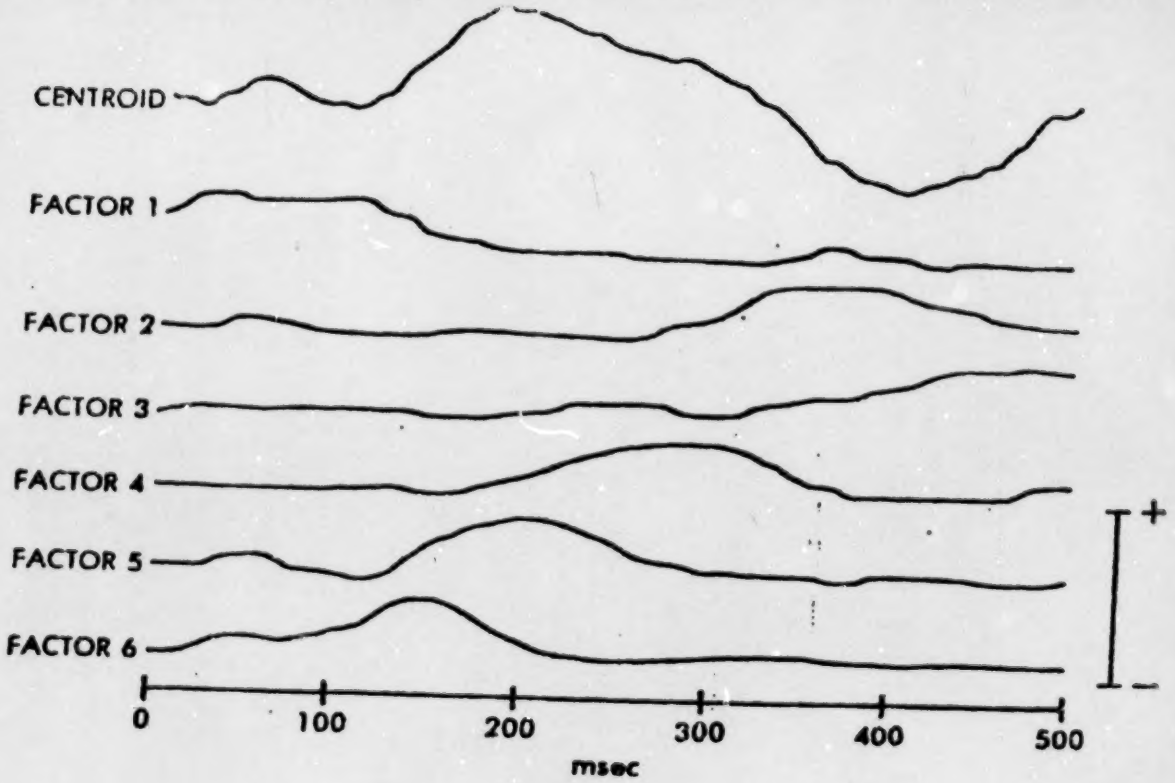
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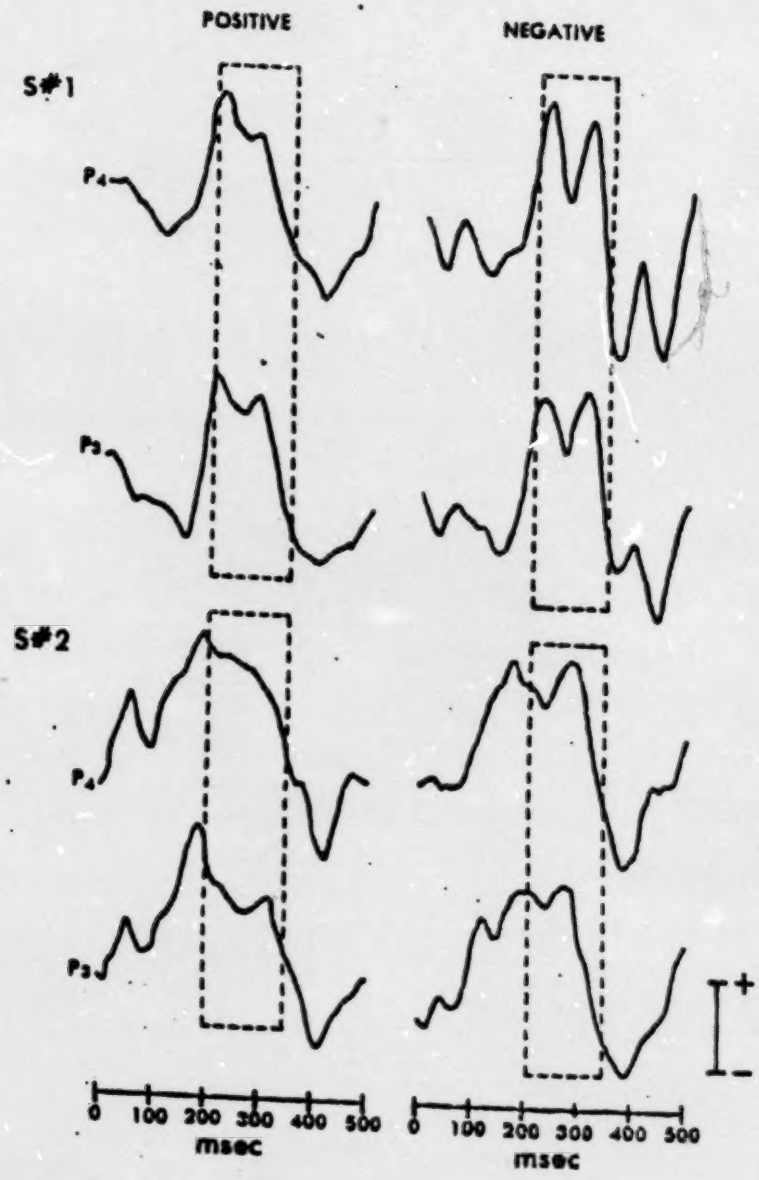

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Fig 2.